Combined limit for searches for 1st and 2nd generation LQ

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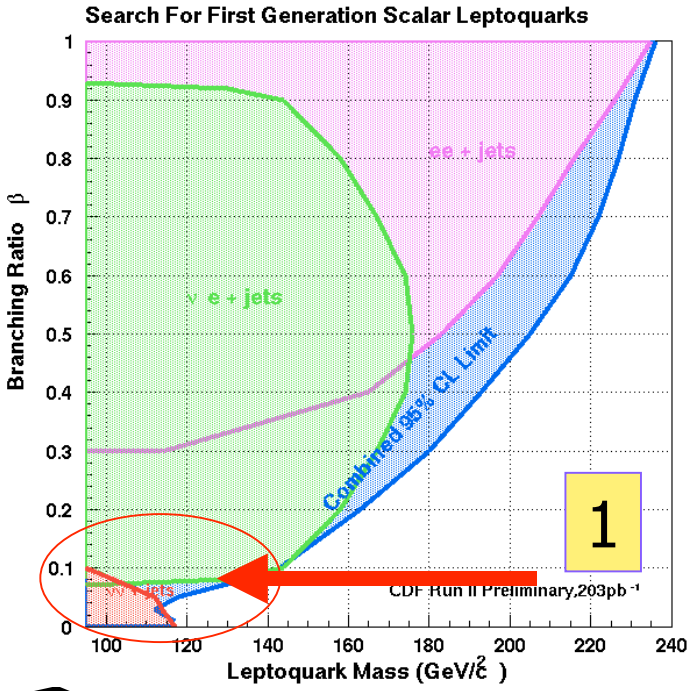
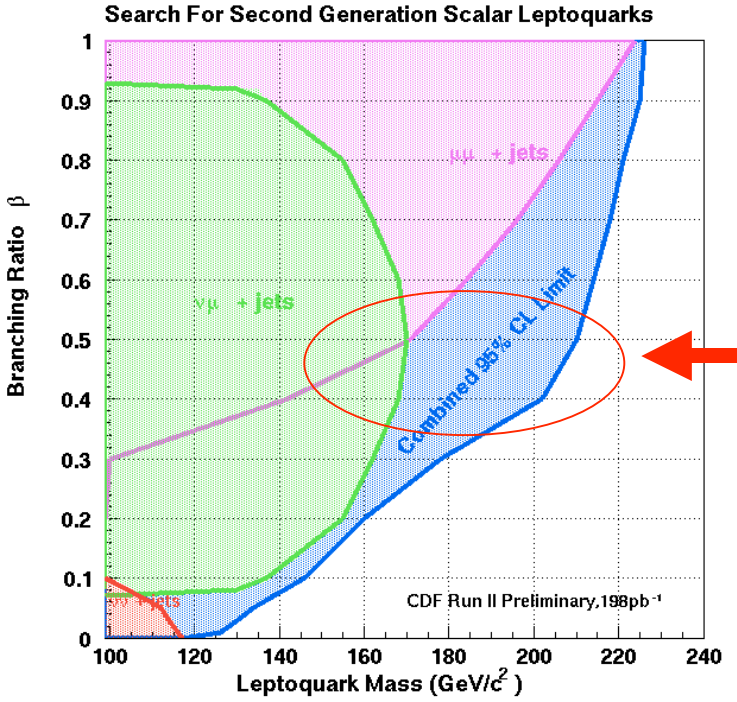
Issues from Last Year..

The combined plots for 1st and second generation do not look too similar...investigate!





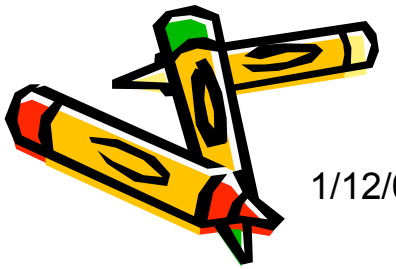
A Reminder on the Combination method

- Bayesian approach: modification of bayes.f
- Joint likelihood formed from the product of the individual channels likelihood.
- For each mass we simulated 10K pseudo-experiments, smearing the calculated number of background events and the estimated number of signal events by their respective total uncertainties.
- The searches in the eejj and e□jj channel use common criteria and sometime apply the same kind of requirements (for example on the tight electron identification) so the uncertainties in the acceptances have been considered completely correlated (which gives the most conservative limit).
- When calculating the limit combination including also the □□jj channel the uncertainties in the acceptances have been considered uncorrelated.A correlation factor of 0.5 has also been considered (no difference)

$$\sigma_{LIM} = N_{LIM}/(\sigma_{average}\cdot\mathcal{L})$$

  - $\sigma_{average} = (\alpha^2\cdot\sigma(eejj) + 2\cdot\alpha(1-\alpha)\cdot\sigma(e\nu jj) + \alpha^2\cdot\sigma(ee \text{ as } e\nu))$ for the 2 channels case and
  - $\sigma_{average} = (\alpha^2\cdot\sigma(eejj) + 2\cdot\alpha(1-\alpha)\cdot\sigma(e\nu jj) + (1-\alpha)^2\cdot\sigma(\nu\nu jj) + \alpha^2\cdot\sigma(ee \text{ as } e\nu))$ for the three channels case.

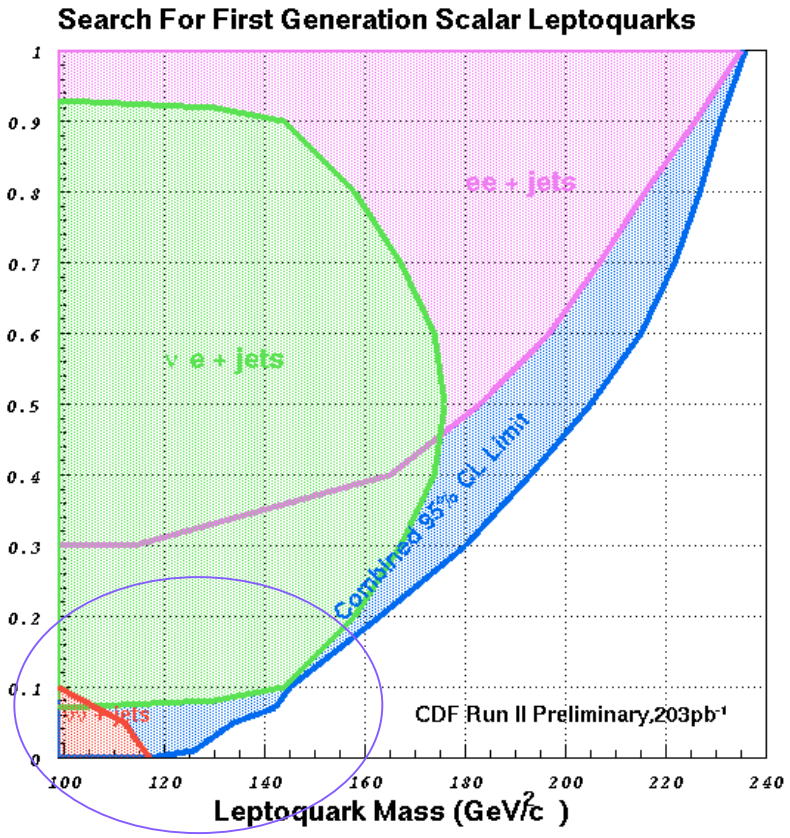
$\mathcal{L} = 203 pb^{-1}$



Issue #1: low □

Re-ran the combination code all points. Found a typo in the input for m(LQ) = 140 GeV/c^2. The 1st generation plot looks now like the 2nd gen at low beta

126 GeV/c^2 (□=0.01)
134 GeV/c^2 (□=0.05)
145 GeV/c^2 (□=0.1)
163 GeV/c^2 (□=0.2)
205 GeV/c^2 (□=0.5)
236 GeV/c^2 (□=1.0)



Issue # 2

The objection: the single channel limits are much worst than The combined limits. Why?

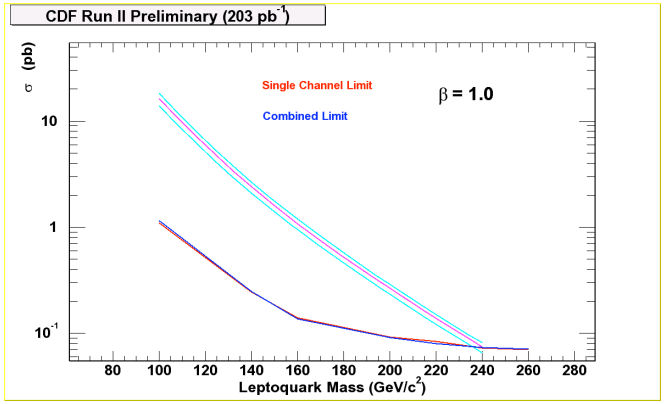
Answer: remember the expression for the combined efficiency:

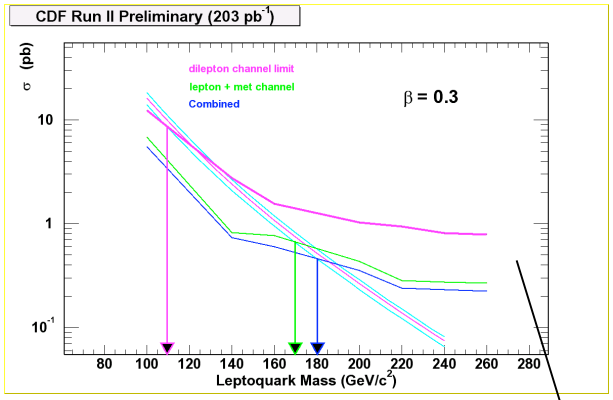
- $\varepsilon_{average} = (\alpha^2\varepsilon(eejj) + 2\alpha(1-\alpha)\varepsilon(e\mu jj) + \alpha^2\varepsilon(ee \text{ as } e\mu))$ for the 2 channels case and
- $\varepsilon_{average} = (\alpha^2\varepsilon(eejj) + 2\alpha(1-\alpha)\varepsilon(e\mu jj) + (1-\alpha)^2\varepsilon(\mu\mu jj) + \alpha^2\varepsilon(ee \text{ as } e\mu))$ for the three channels case.

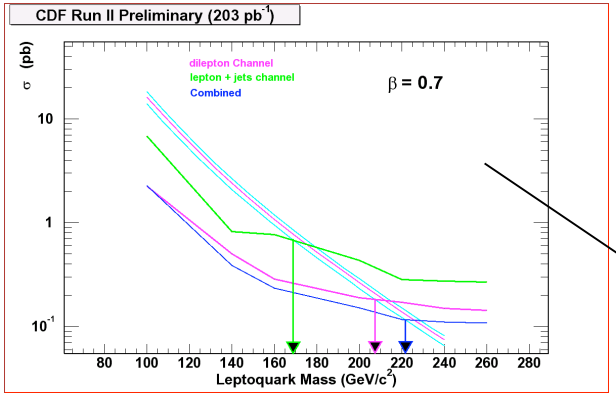
This is the correct efficiency for ALL α

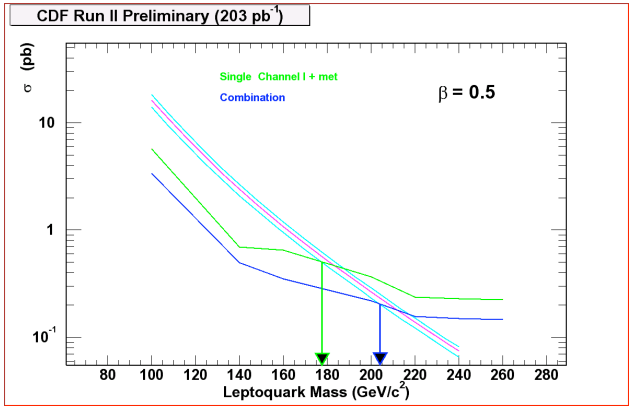
Single channel limits are obtained using efficiency optimal ONLY for $\alpha = 1$ and $\alpha = 0.5$. All other α values are extrapolations in the absence of complete information

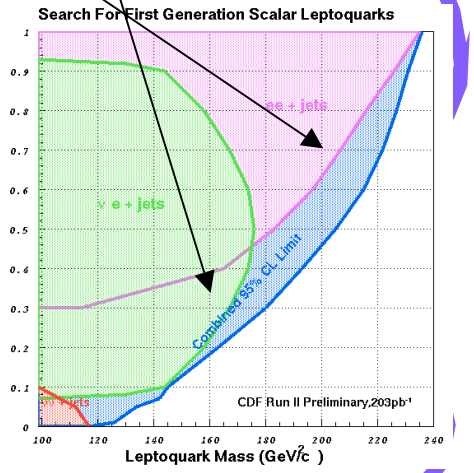
Findings (cont'd)



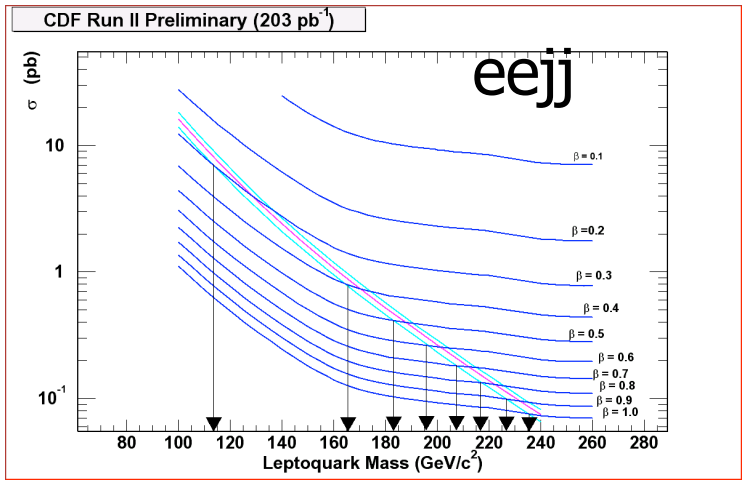






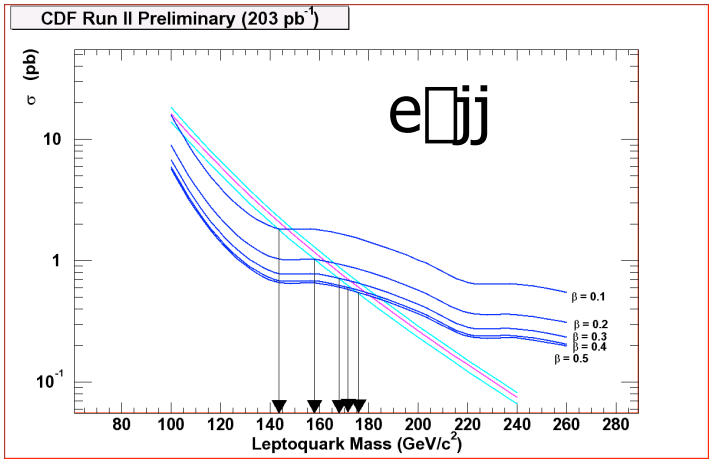


Results: individual channels 1st generation

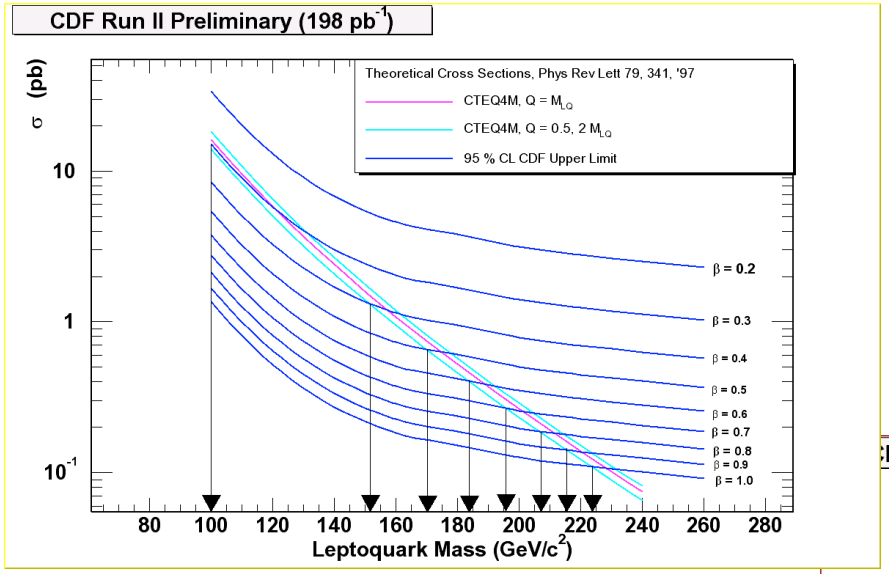


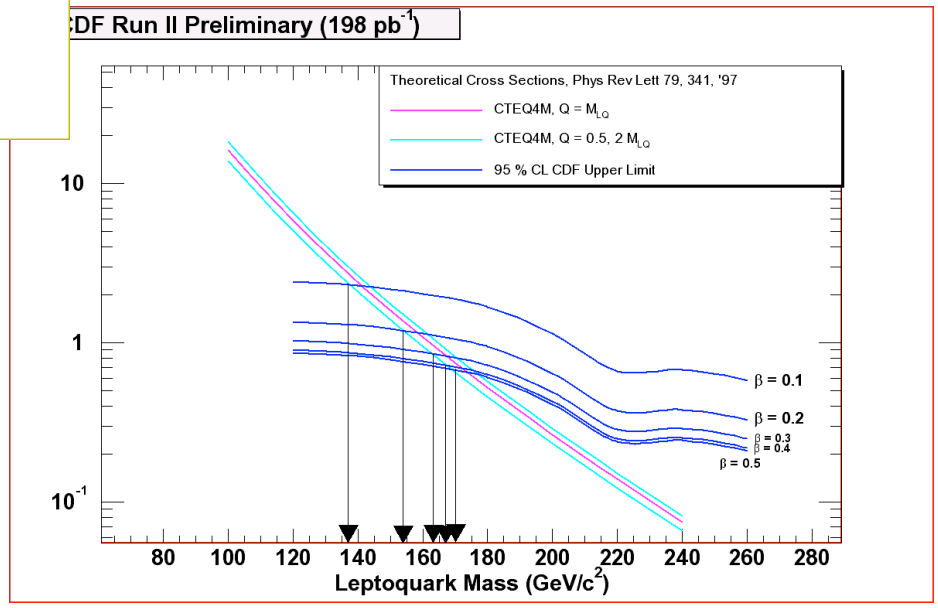
□	mass limit range (GeV/c^2)
0.0	78 - 117
0.01	79 - 116
0.02	80 - 115
0.03	80 - 114
0.04	80 - 113
0.05	84 - 112
0.06	86 - 111
0.07	90 - 110
0.08	not clear

□□jj



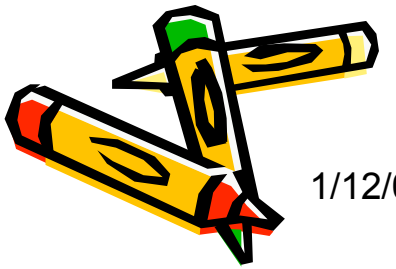
Results: Individual Channels 2nd Gen



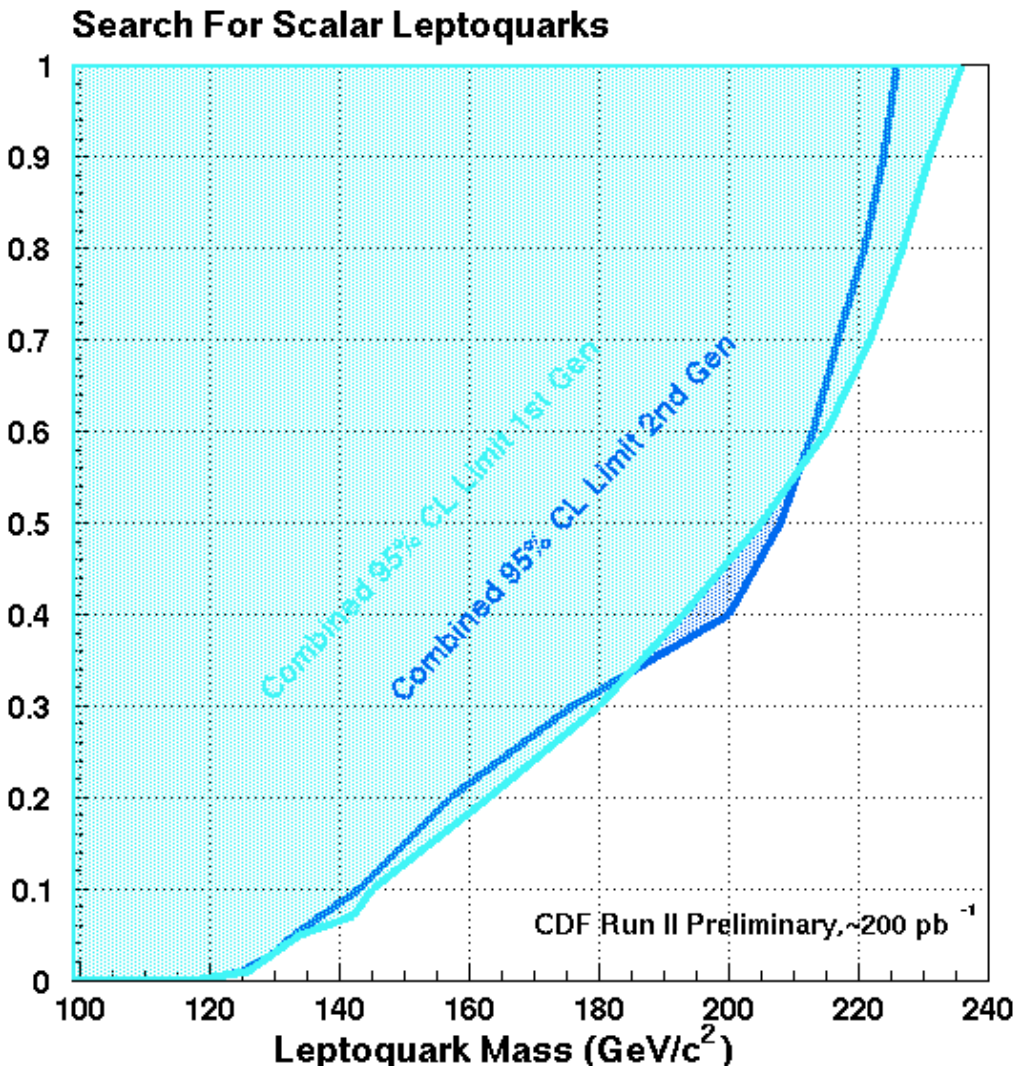


The 2 combined limits

□	1st Gen	2nd Gen
0.01	126	125
0.03	127	130
0.05	134	133
0.07	142	137
0.1	145	143
0.2	163	157
0.3	180	176
0.4	193	200
0.5	205	208
0.6	215	213
0.7	222	217
0.8	227	221
0.9	231	224
1.0	236	226



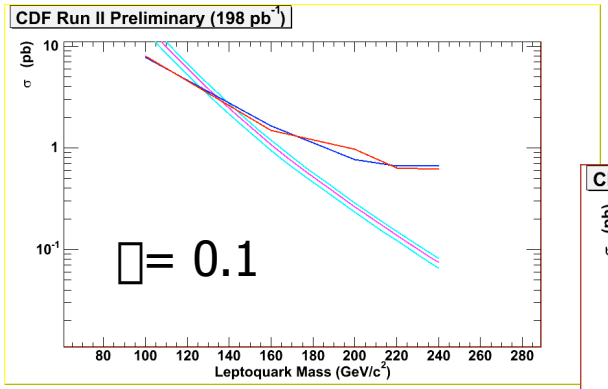
The 2 limits (cont'd)

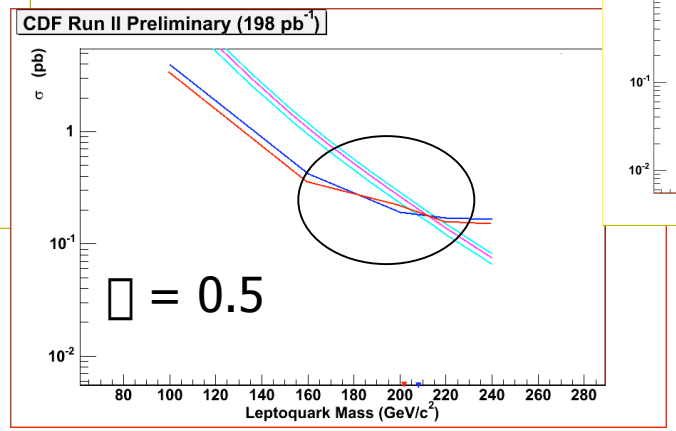


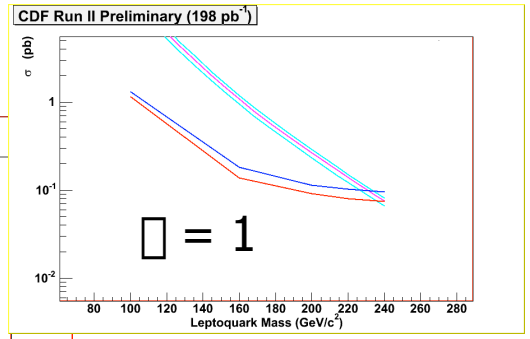
The 2 limits - details

Tested several points for both analysis (these are the points both of them have in common:
m(LQ) = 100, 160, 200, 220, 240
Generally the 1st generation limit curves are lower than the second generation. This implies better limits.
But there are a handful of point for m(LQ) = 200 where the trend is reversed.

0 evts observed in one of the 2nd gen analysis



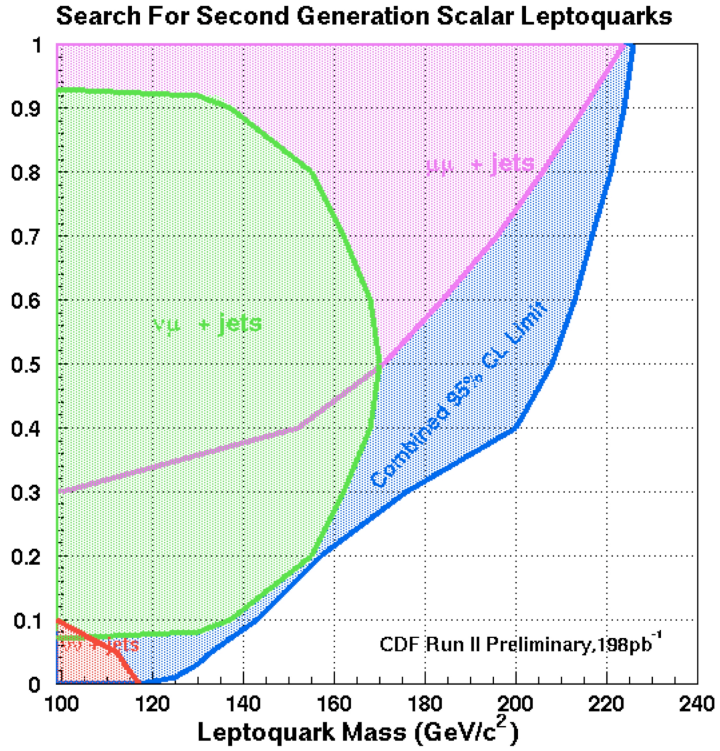




The 2 limits - details

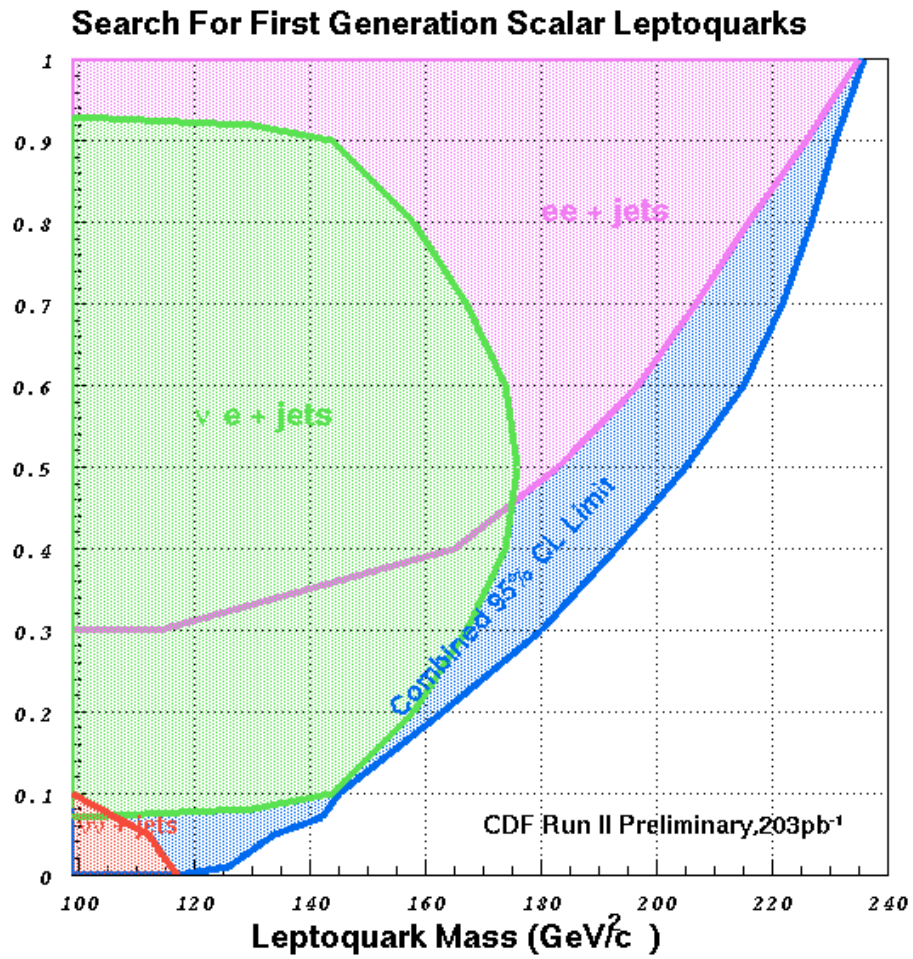
The better limit for 2nd generation for m(LQ) = 200
Could be explained with the fact that in this analysis
The □□ channel did have 0 events observed, while the
e□ had 4 vs an expectation of 4.6 ± 1.0
The code is exactly the same and it runs under the same conditions.
Acceptances are of the same order, as well as the errors.

Remember that observing 0 events will always give the best limit.



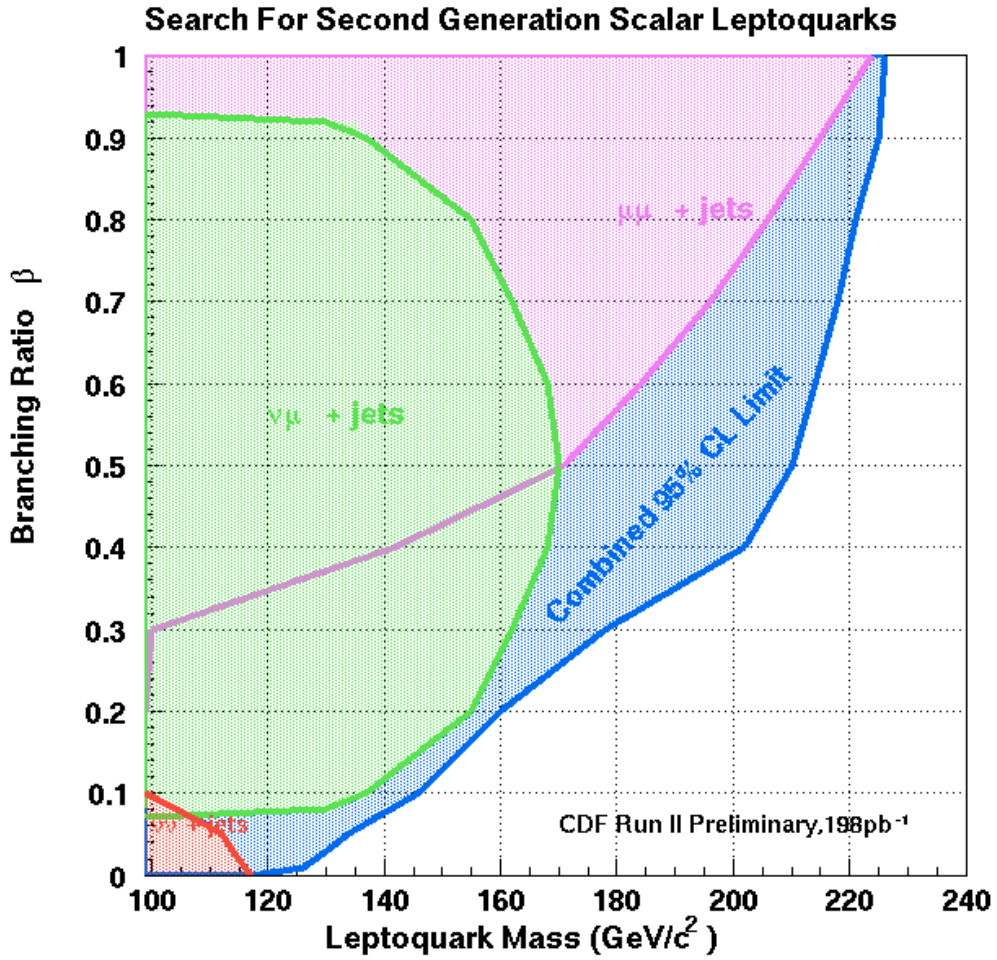
Final Result: 1st Generation

126 GeV/c^2 (β=0.01)
134 GeV/c^2 (β=0.05)
145 GeV/c^2 (β=0.1)
163 GeV/c^2 (β=0.2)
205 GeV/c^2 (β=0.5)
2236 GeV/c^2 (β=1.0)



Final Result: 2nd Generation

125 GeV/c^2 (=0.01)
133 GeV/c^2 (=0.05)
143 GeV/c^2 (=0.1)
157 GeV/c^2 (=0.2)
208 GeV/c^2 (=0.5)
226 GeV/c^2 (=1.0)



Conclusions

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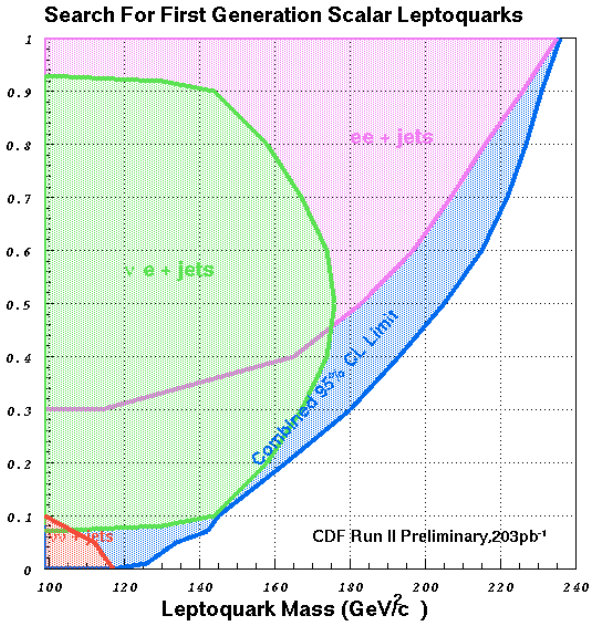
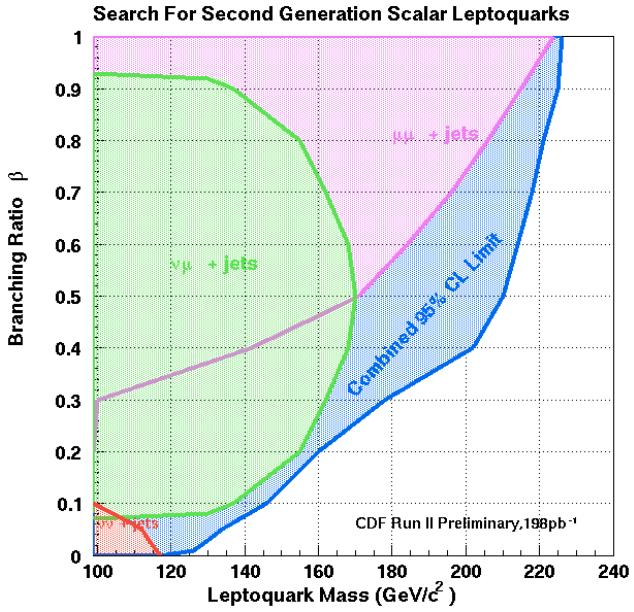
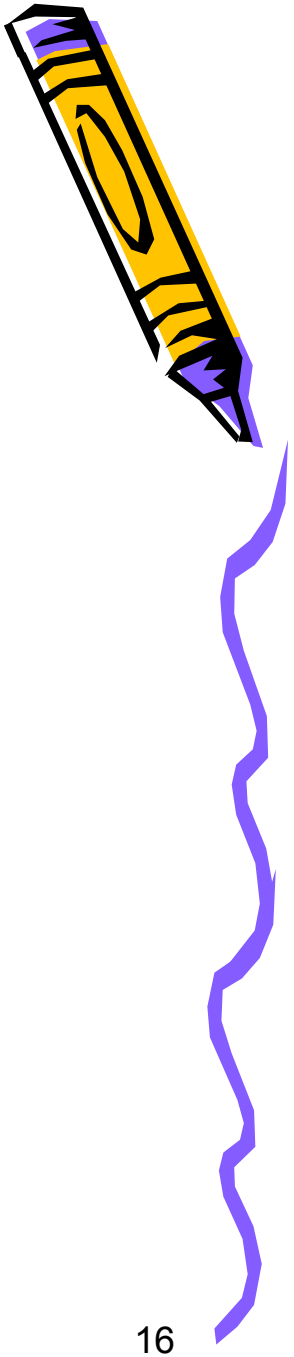
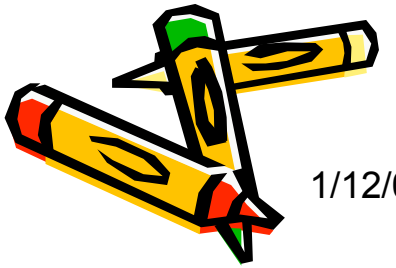
- We have performed the combination of all the CDF searches for first and second generation scalar letpoquarks using Run II data.
- The results are combined using a procedure based on a Bayesian approach which takes into account the correlations in the systematic uncertainties.
- We set 95% CL mass limits for scalar leptoquarks as function of β:





Backup



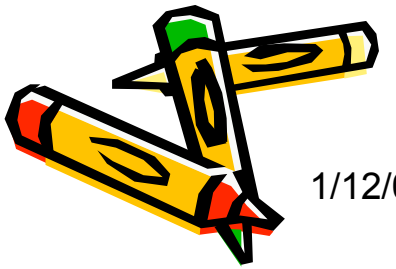


Acceptances I : eejj

Mass	Acceptance	Relative Error
100	0.027	0.07
140	0.12	0.047
160	0.32	0.042
200	0.35	0.045
220	0.38	0.046
240	0.404	0.042
260	0.42	0.041

Background expected:
6.24 ± 2.16

Data: 4 events



Acceptances II : e□jj

Mass	Acceptance	Relative Error
100	0.017	0.13
140	0.085	0.089
160	0.088	0.088
200	0.165	0.081
220	0.19	0.08
240	0.204	0.079
260	0.22	0.079

Background expected:

Mass	100	120	140	160	180	200	220	240	260	280
W+2 jets	1.5±0.9	1.5±0.9	1.5±0.9	2.5±1.13	2.5±1.13	2.5±1.13	2.0±1.0	2.0±1.0	1.5±0.88	0.5±0.5
top	2.7 ±0.6	3.3 ±0.6	3.12 ±0.5	2.8 ±0.5	2.5 ±0.5	2.03 ±0.4	1.63 ±0.4	1.08 ±0.3	0.8 ±0.22	0.6 ±0.21
Z+jets	0.05 ±0.01	0.05±0.01	0.08±0.02	0.08±0.02	0.08±0.02	0.08±0.02	0.06±0.02	0.06±0.02	0.04±0.01	0.04±0.01
Total	4.3±1.03	4.9 ±1.05	4.7 ±1.1	5.4 ±1.2	5.0 ±1.2	4.6 ±1.23	3.7 ±1.06	3.1 ±1.0	2.3 ±0.9	1.1 ±0.6
Data	**7**	**6**	**4**	**4**	**4**	**4**	**2**	**2**	**2**	**1**

Acceptances III: □□jj

			$\sigma_{\rm NLO}$(pb)	
m_{LQ_1} (GeV/c^2)	ϵ_{LQ_1}	$\delta_{\rm tot}$ (%)	$\mu = m_{LQ_1}$	$\mu = 2m_{LQ_1}$
75	0.0073	29	69.4	58.8
80	0.0113	26	49.2	41.5
90	0.0187	23	26.0	22.1
100	0.0300	20	14.6	12.5
110	0.0431	16	8.4	7.4
115	0.0482	15	6.7	5.8
125	0.0590	15	4.2	3.6
150	0.0828	13	1.4	1.3
175	0.1010	12	0.57	0.51

Source	Events expected
$W(\rightarrow e\nu)$+jets	$6.1 \pm 1.4 \pm 1.5$
$W(\rightarrow \mu\nu)$+jets	$21.7 \pm 2.3 \pm 2.8$
$W(\rightarrow \tau\nu)$+jets	$28.4 \pm 3.8 \pm 4.1$
$Z(\rightarrow \mu\mu)$+jets	$1.1 \pm 0.2 \pm 0.2$
$Z(\rightarrow \tau\tau)$+jets	$0.9 \pm 0.2 \pm 0.2$
$Z(\rightarrow \nu\nu)$+jets	$39.1 \pm 2.8 \pm 3.6$
$t\bar{t}$	$4.3 \pm 0.4 \pm 0.3$
QCD	16.9 ± 6.7
Total Events	118.5 ± 14.5

Data : 124

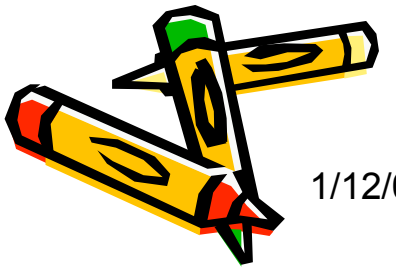
Acceptances IV : □□jj

Mass	Acceptance	Relative Error
100	0.0189	0.17
120	0.04	0.09
160	0.13	0.08
180	0.16	0.08
200	0.19	0.08
220	0.22	0.08
240	0.23	0.08

□□jj

2.87 ± 1.0

Observed : 2



Acceptances V : □□jj

Mass	Acceptance	Relative Error
100	0.0051	0.47
120	0.073	0.07
160	0.051	0.08
180	0.073	0.08
200	0.094	0.07
220	0.109	0.07
240	0.125	0.07

□□jj

Final Selection

	140	160	180	200	220	240	260
W	0.92 ± 0.06	1.44 ± 0.10	1.44 ± 0.10	1.67 ± 0.11	1.65 ± 0.11	0.93 ± 0.06	0.44 ± 0.03
Top	1.69 ± 0.21	1.84 ± 0.23	1.35 ± 0.17	1.00 ± 0.39	0.80 ± 0.29	0.67 ± 0.08	0.52 ± 0.06
Z	0.18 ± 0.01	0.22 ± 0.02	0.19 ± 0.01	0.18 ± 0.01	0.14 ± 0.01	0.05 ± 0.00	0.04 ± 0.00
QCD	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.00
Total	3.09 ± 0.57	3.74 ± 0.62	3.22 ± 0.56	3.08 ± 0.53	2.83 ± 0.51	1.94 ± 0.44	1.30 ± 0.39
Data	3	3	2	0	0	0	0